tation. However, the present embodiment of the display system according to the invention is capable of recognizing predetermined graphical user interface (GUI) objects, such as buttons and sliders, and generate the appropriate relief for these objects. Such an architecture is easily integrated with a separate GUI component, e.g. a X-Windows terminal. Nowadays, graphical operating systems nearly always have a separate layer with predefined graphical objects, whose appearance may be adapted to some extent by the application but whose behavior is predefined. The definition of such GUI objects may be extended with a definition of the appropriate tactile guidance.

[0012] In an embodiment of the display system according to the invention the relief generator is arranged to dynamically generate changes in the relief in response to user actuations, so as to provide tactile feedback. Note the difference between tactile guidance and tactile feedback. Tactile guidance is static (with respect to a present graphical representation) whereas tactile feedback is dynamic, responding to a user actuation. For example, a physical push button initially resists a user pressing it. When the exerted force exceeds a threshold, the button is actuated and the user feels a 'snap' action confirming that the button is actually pressed. In a GUI this snap action is often simulated by changing the graphical representation and sometimes by a clicking or beeping sound. With the present embodiment this can be further enhanced with real tactile feedback. For example, when the user presses a graphical button with sufficient force, an initial protrusion may be suddenly removed or even converted into a depression, giving a clear indication to the user that the button is pressed. In an advanced embodiment, the user is even able to 'push' a slider button along a slider control. To this end, the display system may detect that a user's finger presses both the slider button and part of its environment, and responds by shifting the protrusion 'away' from the finger, opposite the place where the user's finger touches the environment of the slider button. The user can then just retract his finger, or continue sliding the button by following the movement of the protrusion.

[0013] The invention is particularly suitable for data processing devices which utilize touch input for user interaction with the system, e.g. PDA, cell phones etc.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other aspects of the invention are apparent from and will be elucidated, by way of a non-limitative example, with reference to the embodiment(s) described hereinafter. In the drawings,

[0015] **FIG. 1** shows a diagram of a personal digital assistant as an embodiment of the data processing system according to the invention,

[0016] **FIG. 2** schematically shows a cross-section of a display screen comprising a relief generator according to the invention,

[0017] **FIG. 3** schematically shows a cross-section of an alternative display screen comprising a relief generator according to the invention,

[0018] **FIG. 4** schematically shows a display screen comprising a relief generator with tactile feedback capability,

[0019] **FIG. 5** schematically shows another display screen comprising a relief generator with tactile feedback capability.

DESCRIPTION OF EMBODIMENTS

[0020] For consistency and ease of understanding, the same reference numerals are used in different Figures for items serving the same or a similar function.

[0021] **FIG. 1** shows a diagram of a personal digital assistant **100** as an embodiment of the data processing system according to the invention. The PDA **100** comprises a display screen **101**, which is a touch-sensitive liquid crystal display (LCD), capable of displaying graphical representations and sensing touch input by the user. The PDA**100** further comprises hardware push-buttons, e.g. for activating regularly used applications such as an agenda, a calculator, an address list and a note pad. The graphical representation as currently displayed on the display screen **101** comprises a message "Continue?" and two soft-buttons **103** and **104**, respectively for continuing or canceling the current operation. The two buttons **103** and **104** protrude from the display screen **101**, caused by relief generated by a relief generator at locations which coincide with the graphical representations of the buttons. As a result, the user need not carefully watch the screen while operating the screen, since he can feel the presence of the buttons while sliding his finger across the screen. This is very convenient in dark conditions or in a multi-tasking setting. Preferably, the buttons are only actuated when the force exerted by the user exceeds a certain threshold, so that the user can first search the buttons with his finger without accidentally actuating one of them.

[0022] **FIG. 2** schematically shows a cross-section of a display screen comprising a relief generator according to the invention. The display screen comprises an LCD display **201** which may be of conventional type. On top of it is provided a layer **202** of transparent piezo electrical elements constituting the relief generator. Each element can be addressed separately, so as to generate relief at any desired location. The protrusions corresponding to buttons **103** and **104** are depicted in **FIG. 2** from side view. The width of each button corresponds to four protruding elements, while the height of each button may, for example, correspond to two protruding elements. In alternative embodiments the elements can be larger or smaller, dependent on the sophistication of the system. In an ideal case, the elements correspond to individual graphical pixels. The graphical representation of the buttons **103** and **104** can be viewed through the transparent layer **202**. Due to optical refraction of the layer **202**, the graphical representation may be slightly transformed, but this can be turned into an advantage by making the buttons more salient in this way, e.g. through a magnifying effect. The protrusions may be accomplished by activating the relief elements at the corresponding positions so as to cause said protrusions, or complementarily generating a depression at all non-corresponding locations, e.g. by supplying an inverse signal to the non-corresponding elements. Also a combination of the two approaches may be used.

[0023] **FIG. 3** schematically shows a cross-section of an alternative display screen comprising a relief generator according to the invention. In this alternative embodiment the relief generator **302** is located at the rear of the display